

CALIFORNIA FISH AND GAME

"CONSERVATION OF WILDLIFE THROUGH EDUCATION"

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In The Service of Their Country

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Killed in Line of Duty

Byron Sylvester

Arthur Boeke

Richard DeLarge

EFFECT OF HUNTING ON A VALLEY QUAIL POPULATION ¹

By BEN GLADING

*Bureau of Game Conservation
California Division of Fish and Game*

and

ROY W. SAARNI
U. S. Forest Service

One of the most perplexing problems confronting public and private managers of resident game is to determine how large a proportion of the population may be safely harvested annually by hunters. Such studies have been made by various workers on eastern species of small game and on deer, but similar knowledge of the harvestable surplus in valley quail is unknown.

During the investigation of life history and management on valley quail (*Lophortyx californica*) at the San Joaquin Experimental Range ² in Madera County, California, an opportunity was presented to begin a study of shootable surpluses.

The following experiment was devised to determine what percentage of a fall population could be safely killed without damaging the seed stock.

One area of approximately 720 acres was chosen as a hunting ground and another similar plot of about the same size was used as a nonhunting, population check area. These two areas, experimental and control, were chosen to be as similar as conditions would permit. Both were covered with about the same type and amount of brushy cover and were essentially south slope in exposure. Varying rates of cattle grazing at the Range made it desirable to include pastures subjected to the same rates and season of grazing in each. Thus, in each there were included one 160-acre pasture grazed at the rate of one head per 10 acres, one 240-acre pasture grazed at one head per 15 acres, and one 320-acre pasture grazed at one head per 20 acres. All were grazed in late winter and spring only.

To get the same rates and season of grazing in the check or nonhunting area, it was necessary to split the latter into two blocks, one of 160 acres and the other of 560 acres. This manner of splitting up the check area and the nearness of experimental and check areas admittedly was

¹ Submitted for publication, January, 1944.

² A branch of the California Forest and Range Experiment Station maintained by the Forest Service, U. S. Department of Agriculture, at Berkeley, California, in cooperation with the University of California.

The quail study was under the guidance of a committee composed of Tracy I. Storer, chairman, and J. T. Emlen, Jr., of the University of California College of Agriculture; E. E. Horn and H. S. Fitch of the U. S. Fish and Wildlife Service; Gordon H. True, Jr., of the California Division of Fish and Game; E. I. Kotok, M. W. Talbot, H. H. Biswell, J. Bentley, and J. W. Nelson of the California Forest and Range Experiment Station, U. S. Forest Service; and F. P. Cronemiller and Ivan Sack of Region 5, U. S. Forest Service. Messrs. Storer, Horn and Cronemiller formed a special technical advisory committee. Funds for the project were supplied by Region 5, U. S. Forest Service. The authors were engaged by the Committee as resident investigators at the Range (Glading, 1936-40; Saarni, 1941-42). Additional help in various projects was obtained through the use of U. S. Forest Service Junior Assistants to Technicians and Civilian Conservation Corps enrollees for manual labor. Studies began in December, 1936, and were suspended in 1942.

undesirable, but necessary because of the lack of other available areas comparable in cover, amount of water, slope and degree of grazing.

To provide a further control, the spring censuses of the hunting area were compared with spring censuses of the entire Range (3,000 acres, 1936-38; 4,000 acres, 1939-42).

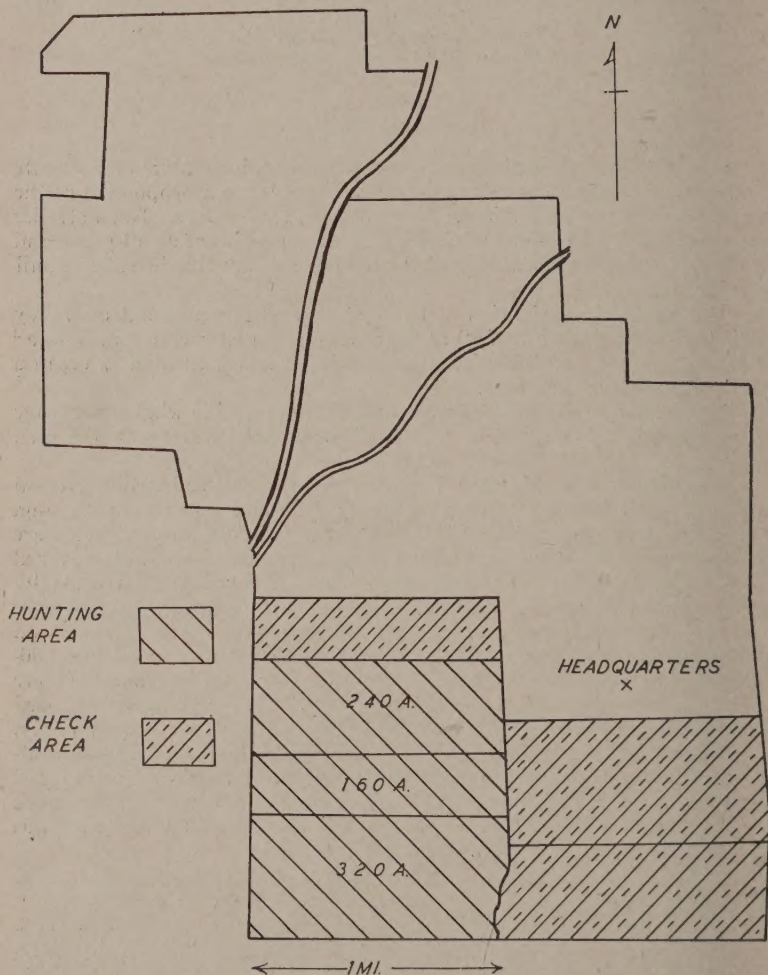


FIG. 33. San Joaquin Experimental Range, showing entire extent and also the hunting and check areas.

When first designed, it was hoped to conduct the experiment under several different degrees of hunting, increasing gradually until the maximum permissible hunting pressure was determined. Premature

suspension of the project due to war time conditions precluded this, and hence only the initial stages of the experiment are presented here.

Annual quail censuses had been taken of the entire Range starting in March of 1936 (Glading, 1941). These annual counts were used as the basis for pre-experimental period censuses of the hunting and control areas, and for the post-season counts after the hunting experiment was started in 1938.

Prior to each hunting season, a horseback census was made of each area and the number of quail was recorded. Plans were made for removing a bag of 25 per cent of the birds counted in the pre-season census. It was estimated that each hunter would take an average of seven quail; enough hunters, therefore, were sought to effect the desired removal. After each hunting season, another census was made of the areas. This entire procedure was carried out in each of four consecutive years starting in November, 1938.

Hunters for the experiment were chosen by the Madera County Sportsmen's Club with Mr. E. E. Nelson acting as coordinator between the Quail Committee and the club. The following memorandum was sent to Mr. Nelson prior to each hunting season.

1. Approximately ---- hunters will be chosen by you to help us out in getting figures on known hunting pressures on known quail populations.
2. These men will hunt one day apiece on designated areas of the San Joaquin Experimental Range.
3. The hunting days will be spaced so that no more than three men may hunt during any one week, and the first, third, and last week of the season must have at least two hunters per week.
4. These hunters will be allowed to take the State bag limit (10 birds) during their one day each of hunting.
5. The hunters must check in at the headquarters before hunting to receive further instructions as to exact area to be hunted, etc.
6. Hunters will check in after the hunt in order to check the bag and to have crops removed from the birds for stomach examination.
7. The exact number of hunters to be chosen by you to hunt during the season will be given to you on or before November 12.
8. You will have entire say as to the choice of hunters for the experiment. It is hoped, however, that lots be drawn, or some other chance method be used in selecting the men in order that the groups will represent as nearly as possible a true cross-section of the hunting population.

The hunters were to represent as nearly as possible a reasonable cross-section of those who ordinarily would hunt quail in the Sierra foothills. About equal numbers were chosen from among local ranchers and residents of the town of Madera or other nearby communities. How close an approximation of representative hunting ability was obtained is a matter of conjecture. A total of 38 individual hunters took part during the four years, comprising in all, 58 hunter visits.

Hunters were given a sheet of instructions and also a map of the hunting area, on which was shown the location and numbers of quail by

coveys as determined in the pre-season census. In general, the hunters were not accompanied by any of the Range staff while hunting, but each was asked to check out his bag and to submit to an oral questionnaire at the end of his shoot. All of the hunters complied with the regulations, so that the figures for total birds in the bag are considered accurate. The sheet of instructions given to each cooperating hunter reads as follows:

Suggestions to Hunting Experiment Cooperators

The purpose of this experiment is to secure data on the effect of a known hunting effort on a known population of quail. There are more than ---- valley quail on the hunting area and it is planned to take off approximately 25 per cent (about ---- birds) in this experiment. Future censuses will be made to determine the long time effect of such an annual cropping rate. Through your cooperation, figures will also be obtained on age and sex ratios, cripple-kill ratio, predator counts, and other data. In order that mutual benefit will be secured from the results of this hunt, it will be appreciated if you will observe the following suggestions:

1. Check in at the headquarters of the San Joaquin Experimental Range for instructions and a map of the hunting area.
2. Confine your hunting entirely within the boundary of the hunting area.
3. Do not shoot hawks, owls, jays, or any birds or mammals except valley quail.
4. Keep a check on the number of birds crippled but not secured.
5. Keep a count of the number of Cooper's hawks (blue darters) seen.
6. Keep a count of the number of shells used. (These figures may be used later in obtaining rough estimates of quail population of other areas of similar cover conditions. This data is not intended as a check on your ability as a hunter!)
7. Check out at the headquarters building where a member of the staff will check your birds as to age, sex, and weight, and remove the crops for a food habits study. You will, of course, retain the birds.
8. California Fish and Game laws as to bag limit, etc. are to be complied with in the conduct of this hunt.

We thank you very much for your cooperation in conducting this hunt and sincerely hope that you will have a successful day.

(Signed) Cooperative Quail Management Committee

After the day's shoot, each hunter was questioned on the following: Time started to hunt, time stopped hunting (man hours), type of gun used, bore of gun, size of shot, number of birds in the bag, number of birds crippled but unretrieved, whether or not a dog was used, number of Cooper's hawks seen, and number of shells used. In addition, each was asked for his opinion on the number of quail present.

Hunters were spread out during the season (November 15-December 31) in about the same manner as occurs under normal quail hunting—the intensity of hunting greatest near the opening of the season and

dwindling toward the end. As each season progressed an attempt was made to regulate the remaining number of hunters so that as near 25 per cent of the pre-season quail population was killed as was practicable.

In addition to the information derived from the above oral questioning, every quail bagged was examined for age and sex, weighed, sampled for blood parasites, and the crop removed for a food habits study. These data made up parts of other reports on the San Joaquin Experimental Range quail studies (Glading, Biswell, and Smith, 1940; Storer, Horn, Glading and Saarni Ms.).

Results

The percentage of the pre-hunting season population taken off during each of the four years was as follows: "In the bag," 1938, 26.5%; 1939, 25.3%; 1940, 18.6%; 1941, 24.1%. Unavoidable complications during the 1940 hunting season accounted for the smaller kill in that year.

Table 1 summarizes for each year the pre-season quail censuses, the number of quail bagged, the reported number of unrecovered cripples, and the post-season census. For the check area, only pre-season and post-season counts are given.

TABLE 1

Summary of Census Data and of Bag and Cripple Losses in Experimental Hunts, San Joaquin Experimental Range, 1938-1942

<i>Hunting Area</i>	1938-39	1939-40	1940-41	1941-42
Pre-season (November) census.....	513	245	278	349
Total bag	136	62	52	84
Unrecovered cripples	57	26	14	25
Total bagged and crippled.....	193	88	66	109
Post-season (March) census.....	214	141	167	184
<i>Check Area</i>				
Pre-season (November) census.....	349	288	256	325
Post-season (March) census.....	257	185	216	202

The information gathered from questioning the hunters of possible importance in evaluating quail populations by hunter success is shown in Table 2. Table 3 compares the number of cripples reported by hunters using dogs versus those without dogs. The types of shooting equipment used by individual hunters are summarized in Table 4.

TABLE 2

Miscellaneous Data on Hunter Success in the Experimental Hunts

	1938	1939	1940	1941	Totals	Averages
Number of hunters.....	21	10	11	16	58	—
Pre-season quail population.....	513	245	278	349	1385	—
Total birds bagged.....	136	62	52	84	334	—
Birds per hunter.....	6.5	6.2	4.4	5.2	—	5.76
Birds per man-hour.....	1.4	1.4	.9	1.0	—	1.18
Cripples per bag of 10.....	4.1	4.2	2.7	3.0	—	3.65
Shells used per bird in the bag.....	3.7	3.3	3.7	3.4	—	3.53

TABLE 3

Comparative Crippling Losses Experienced by Hunters Accompanied by Dogs
Versus Hunters Unaccompanied by Dogs

	1938	1939	1940	1941	Total	Average
Number of hunters using dogs-----	8	0	4	7	19	---
Cripples per bag of 10 with dogs-----	1.5	--	3.2	0.3	--	1.47
Number of hunters without dogs-----	13	10	7	9	39	---
Cripples per bag of 10 without dogs-----	6.4	4.2	2.4	4.4	--	4.71

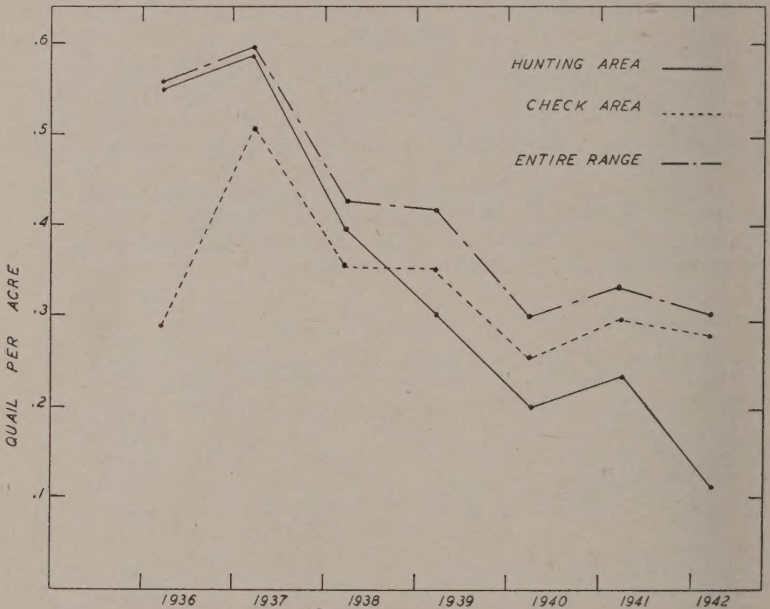


FIG. 34. Valley quail population densities as determined by horseback census in March of each year for the hunting and check areas (hunting began November, 1938). The population densities for the entire range included as an additional control.

Figure 34 shows the population trends as revealed by the spring or post-season counts only. In addition to data for the hunting and control areas, counts for the entire Experimental Range are given as an additional check.

Figure 35 displays the population trends, in birds per acre, on the hunting and check areas for three spring counts prior to the start of the experiment in November, 1938. Pre-season and post-season counts are depicted in this graph after November, 1938.

Discussion

A study of Figure 34 (summary of March censuses on hunted and unhunted areas) will at first glance give the impression that hunting has resulted in a considerable reduction of quail on the hunted area. It must be realized, however, that these counts were all taken in March,

after the hunting season, and that in addition to natural losses, the hunted area has had up to 40 per cent loss each year by birds brought to bag and those crippled. Figure 35, which has both pre-season and post-season counts represented, gives a truer representation of what actually has happened. Each year the March census showed the hunted area population to have dropped below that on the check area, yet, by the next autumn, the two populations were nearly equal; in fact, during the last two years, the hunted area showed a few more birds than the unhunted.

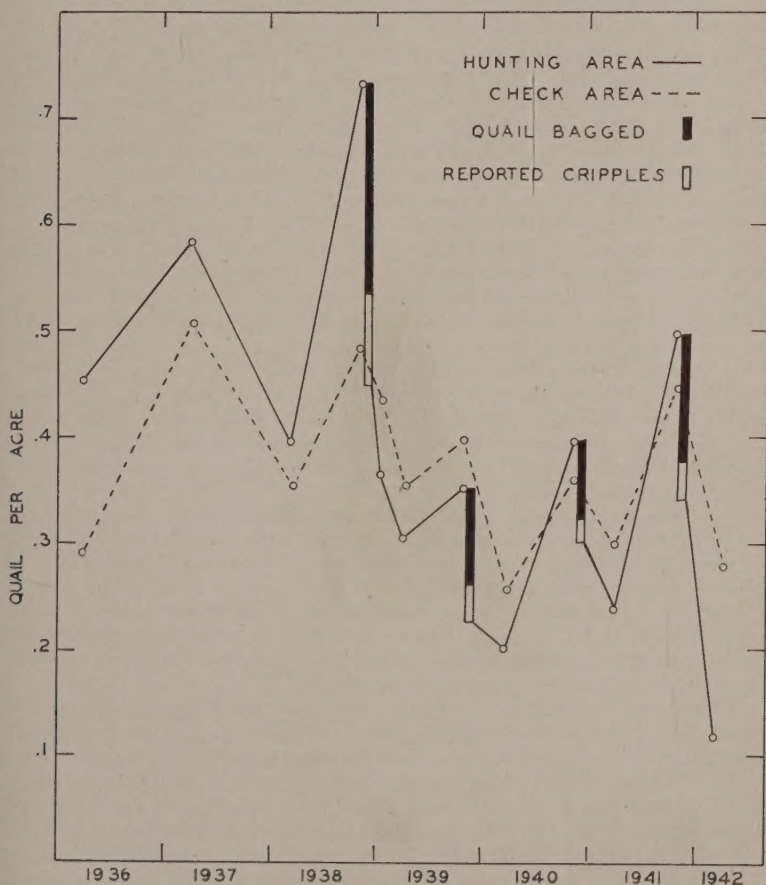


Fig. 35. Population densities of valley quail on the hunting and check areas, based on both pre-season and post-season censuses after the beginning of the hunting experiment (November, 1938). The bars show, per acre, the number of birds bagged and the crippling losses. Suspension of the studies in 1942 unfortunately precluded any opportunity to ascertain whether the great decrease in that year would be overcome subsequently.

Figure 34 shows that the population density in March, for the years following hunting, were lower on the hunting area than on either the

check area or the entire Range; yet the same general trend in population is exhibited by all three curves. Thus, from the peak in March, 1937, all three curves show a marked decline through the first two years of the hunt (1938-39, 1939-40), then a slight rise (1940-41), followed by another drop (1941-42). This suggests that other factors, admittedly unknown to us, are far more important than a moderately heavy hunting season kill.

The best objection to the above conclusions is that movements of birds from the unhunted area to the hunted area were chiefly responsible for the "come-back" exhibited annually on the hunting area. Fortunately, a partial refutation of this objection is available from the extensive banding program (since 1936) in the areas east of and adjacent to the hunting area. For two years prior to and during most of the course of the hunting experiment, many (764) quail were banded in an area about 100 to 1,500 yards east of the northern half of the hunting area. Only three of these banded birds were subsequently shot in the annual hunts. Two of them were taken not more than 100 yards from the east boundary, and only one well inside of the hunting area. This indicates that wholesale movement did not occur from the east.

The adjacent country to the west and south of the hunting area was privately owned and open to shooting. While the exact degree of hunting on that land was unknown, it was felt to be comparable to the hunting effort on our experimental area. Hence, overflow was not likely to come from those directions.

Census errors could be a factor in misinterpretation, but every possible precaution was taken and the counts are thought to be reasonably accurate (Glading, 1941).

Probably the greatest source of error was in the comparatively small size of the experimental area; greater acreages would minimize the effect of coveys wandering across boundaries during censuses.

At the start of the experiment it was believed that some use later could be made of such figures as birds per hunter, birds per man hour, or shells per bird in the bag for determining an unknown population of quail. Examination of the results, as shown in Table 2, indicate that such figures probably are not correlated to any degree with the number of quail available. At least if any correlation is present, it certainly is not in direct ratio. The above-mentioned ratios, therefore, do not seem to be indices of quail density on this area.

Table 3 indicates that hunters using dogs recovered more crippled quail than those without dogs. The former group lost an average of 1.47 quail per bag of 10, versus 4.71 unrecovered per bag of 10 by hunters without dogs. A personal element, however, is likely to creep in here since dog owners, in their pride, may have biased the results to some degree by a little bragging. The senior author, being a staunch dog addict, recognizes this failing in the clan.

Table 4 is of only local significance, indicating that the preferred quail hunting equipment was a 12-gauge, double barreled gun using No. 7½ shot. Too many individual combinations of gun caliber, model, and shot size were used to obtain any correlation as to which combination was the most effective.

TABLE 4

Summary of Types of Shooting Equipment Used by Individual Hunters,
San Joaquin Experimental Range

<i>Type of Gun</i>	<i>Number of Hunters</i>
Double barrel -----	17
Pump -----	12
Automatic -----	9
<i>Gauge of Gun</i>	
12 gauge -----	24
16 gauge -----	8
20 gauge -----	5
.410 gauge -----	1
<i>Size of Shot Used</i>	
No. 6 -----	1
No. 7½ -----	22
No. 8 -----	7
No. 9 -----	8

No value was placed on answers to the question, "How many Cooper's hawks were seen?" since this seemed to depend on the hunter's ability to recognize Cooper's hawks; few could.

Comments by hunters on the number of quail present likewise were meaningless. In general, if a hunter had good success he reported, "There are plenty of quail"; but if his take was small, "The population is down." Then, too, the hunters were more or less aware of the comparative numbers of quail counted in the census, which probably tended to bias the answers to this question.

Summary

1. The observed valley quail population on the San Joaquin Experimental Range was apparently able to withstand an annual bag kill of 25 per cent of the fall population plus the incident cripple loss.
2. Reasonable hunting is less likely to affect a valley quail population through a series of years than are other factors.
3. Movement of quail probably did not play a major part in replenishing their numbers on the hunting area. This was indicated by the results from an extensive banding program carried on to the east of the hunting area.
4. Hunting and check areas several times larger than those used in this study are desirable to minimize boundary effects (local movements, etc.).
5. No apparent correlation was found between the pre-season number of quail and the birds taken per hunter, birds per man hour of hunting, or shells used per bird bagged.
6. There is indication that hunters using dogs lost fewer quail as cripples than those without dogs.
7. The favorite shooting equipment was a 12-gauge, double barreled gun using No. 7½ shot.

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1940. Studies on the food of the California quail in 1937. Journal of Wildlife Management, vol. 4, 128-144.

THE FOOD OF THE BLACK-SPOTTED TROUT (*Salmo clarkii henshawi*) IN TWO SIERRA NEVADA LAKES

By A. J. CALHOUN¹
Stanford University

Upper Blue Lake and Heenan Lake lie in Alpine County, California, at elevations of 8,130 and 7,100 feet, respectively. Both lakes contain populations of black-spotted trout (*Salmo clarkii henshawi* Gill & Jordan), the native cutthroat of the east slope of the Sierra Nevada. This is the only species of fish in Heenan Lake. In Blue Lake there are also rainbow trout and rainbow-cutthroat hybrids, but together they constitute less than one per cent of the total trout population. A single species of minnow (*Rhinichthys oscula*) is present in Blue Lake.

Blue Lake is roughly a mile long, and half as wide, with a surface area of 344 acres. Heenan Lake has a surface area of 140 acres. They are about as dissimilar as two lakes could be, in spite of the fact that they are less than 15 miles apart, and are near enough the same size to be biologically comparable.

Blue Lake, almost on the crest of the Sierra, drains to the west. It lies in a deep, natural granite basin in a sparsely forested region with an annual snowfall in the neighborhood of 10 feet. A 28-foot dam raises the original level; maximum depth is 177 feet when full (see Fig. 39 in this magazine for a depth contour map). It is rich in dissolved oxygen. A sharp thermal stratification develops two or three weeks after the ice melts, which it usually does in June, and is maintained during the summer. The maximum surface temperature attained in 1940 and 1941 was 68° F. The water is clear. A Secchi disk is ordinarily visible to a depth of about 30 feet. The bottom fauna was found to average 134 pounds per acre, wet weight, during the summer of 1940, on the basis of 45 Ekman dredge samples. The littoral fauna is very poor.

Heenan Lake lies on the other side of the divide from Blue Lake, on the drier eastern slope of the Sierra, in a sage brush region which has a lighter snowfall. It is entirely artificial, being formed by a 35-foot dam built across a gently sloping swampy meadow formerly grazed by cattle. Maximum depth was only 24 feet in 1940 and 1941. Observations made during 1941 indicated a maximum surface temperature of about 70° F. for that year. The shallowness of the lake prevented the development of thermal stratification. Frequent strong winds kept the water well mixed during the summer of 1941. The organic content of the water was so great that there was a pronounced odor of decaying plankton around the shore in late summer. At that time, the visibility depth of a Secchi disk was less than three feet in the middle of the lake, and fell to practically zero around the shore. The dissolved oxygen was depleted at the

¹Submitted for publication, December, 1943. The work on which this paper is based was done under the auspices of the California State Division of Fish and Game, in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Stanford University.

bottom of the lake early in the summer, but the turnover resulting from wind action was adequate to prevent stagnation from reaching a stage dangerous for the trout population. The bottom fauna in the littoral zone was fantastically rich. Stretches of muddy bottom were literally covered with swarms of aquatic insects, scud (*Gammarus*) and snails. Along the face of the dam, rocks the size of a grapefruit carried 15 to 25 scud, together with snails, caddice pupae, notonectids and planaria upon their lower surfaces. The corresponding littoral fauna of Blue Lake was so poor that it was ordinarily difficult to find organisms of any sort around the shore except at the mouths of the tributary creeks.

The difference in amount of food available for trout in the two lakes is reflected in the much better condition of Heenan Lake trout as compared to those in Blue Lake. In the length range from 30 cm. to 40 cm. (2.54 cm. = 1 in.), they averaged from 3 to 8 ounces heavier than Blue Lake trout of the same length. At the same time, Blue Lake trout were by no means thin, and are probably nearer the norm for the species than those in Heenan Lake.

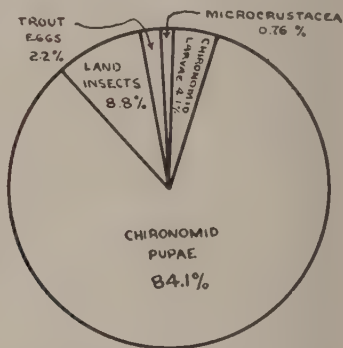
Trout stomachs were collected at Blue Lake during the summers of 1939, 1940 and 1941; and at Heenan Lake in 1941. The results of the analyses of these stomachs are presented in the form of pie diagrams in the accompanying figures.

In carrying out the analyses, the contents of an individual stomach were placed in a watch glass. The various foods were then sorted out, and a visual estimate was made of the percentage by volume of each sort of food in each stomach. In arriving at the condensed results in the pie diagrams, the following method was used. Each stomach was weighted according to the amount of food it contained. Three degrees of fullness were recognized, defined as follows: (1) very full—walls of stomach distended with food, (2) moderately full—stomach cavity filled or nearly so, but walls not distended, and (3) nearly empty—stomach cavity not nearly filled. The percentage of a given food in an individual stomach was multiplied by an appropriate factor (1, 2 or 3, depending on whether they fell into category 3, 2 or 1, respectively, as defined above). The resulting products were then added for all fish in a series, taking each food separately. The summation for an individual kind of food, taken as a percentage of the corresponding summation for all foods, yielded the final figures which were used in making the diagrams. This method gives, essentially, the average per cent by volume of a given food in all stomachs of a series. The weighting of the stomachs according to their degree of fullness provides that fish which have been feeding most actively will contribute more strongly to the final figure than those which have nearly empty stomachs. It also discounts the importance of nearly empty stomachs containing a few atypical organisms.

Figure 36 contains the condensations of the results of analyses of stomachs from Blue Lake trout taken during the summers of 1939, 1940 and 1941. These fish were all between 27 cm. and 43 cm. long. The diagrams in this plate are divided roughly into four seasonal groups, based upon conditions at the lake, to facilitate the comparison of the series for the different years. Each vertical row contains series which are comparable insofar as season of capture was concerned. To give an idea of the relative advancement of the season in the different years, the

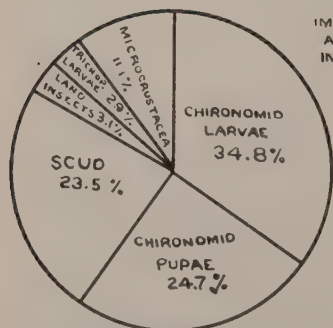
final melting of the ice from the lake took place May 11, June 10 and June 22 in 1939, 1940 and 1941 respectively.

Taking the summer as a whole, the most important foods of the Blue Lake trout were larval and pupal chironomids, commonly called "blood worms"—the immature aquatic stages of small two-winged flies or midges. Microcrustaceans (daphnia and copepods), terrestrial insects, and immature stages of various aquatic insects other than chironomids, followed in that relative order of importance. Chironomid pupae were far and away the most important single food, for they constituted a major part of the diet of the fish during the early summer, when feeding was heaviest, and they were present in all samples in important amounts. There was a change in the relative proportions of the different foods as the season progressed. Immature chironomids became decreasingly important at the same time that other foods, notably microcrustaceans, increased in importance. This shift in the kinds of food eaten was accompanied by a decrease in the quantity of food found in individual

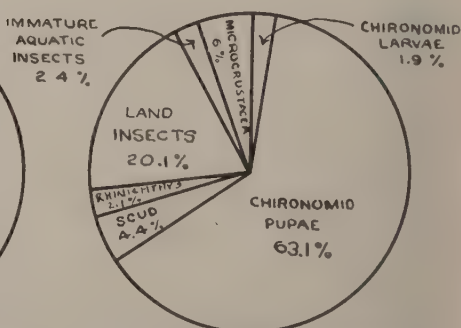


JUNE 27 TO JULY 22, 1940
38 STOMACHS

FIG. 36a. Stomach contents of Blue Lake trout 27 to 43 cm. long during three summers, 1939-1941.



JUNE 20 TO JUNE 29, 1941
20 STOMACHS

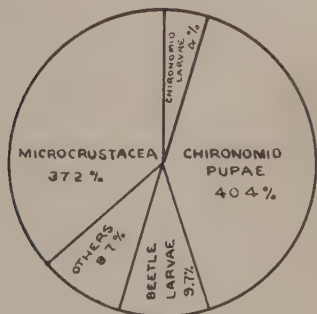


JULY 6 TO AUG. 13, 1941
77 STOMACHS

stomachs, in general. Those taken in June and July were commonly filled almost to bursting with chironomid pupae alone. The estimated numbers of pupae in three such stomachs, from fish 32, 33 and 34 cm. long, containing 20, 21 and 28 c.c. of food, were 9,615, 9,849 and 13,132, respectively. After late July nothing even approaching such a condition was found except in rare instances where individual fish had eaten great numbers of terrestrial insects. In August and September, stomachs typically contained from 1 to 5 c.c. of food.

The only evidence of cannibalism appeared in the late summer of 1940 following the introduction of 50,000 fry into the lake.

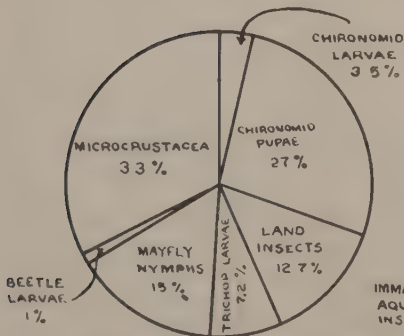
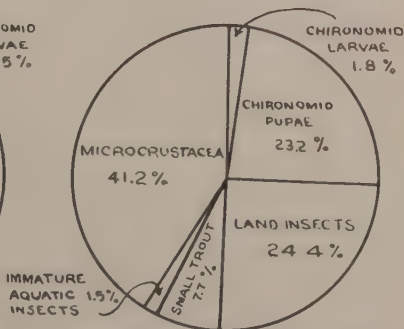
The almost complete absence from the stomachs of the small minnow (*Rhinichthys oscula*) which is abundant in the shallows around the lake came as a considerable surprise. Only three stomachs of a total of 267 examined contained minnows, and each of these had only one. The most probable explanation for the failure of the trout to utilize these minnows for food lies in the observed fact that the minnows confine their activities during the summer to the very shallow water around the shore of the lake, where they are beyond reach of large trout. On several



JULY, 1939

33 STOMACHS

FIG. 36b. Stomach contents of Blue Lake trout 27 to 43 cm. long during three summers, 1939-1941.

JULY 25 TO AUG. 24, 1940
38 STOMACHSAUG. 25 TO SEPT. 19, 1940
48 STOMACHS

occasions trout were observed in obviously unsuccessful pursuit of small schools of them.

It will clearly be inadvisable to introduce *R. oscula* into lakes under conditions comparable to those at Blue Lake with the idea in mind of improving feeding conditions for the trout. They are not consumed in significant quantities, and in addition they may compete seriously with

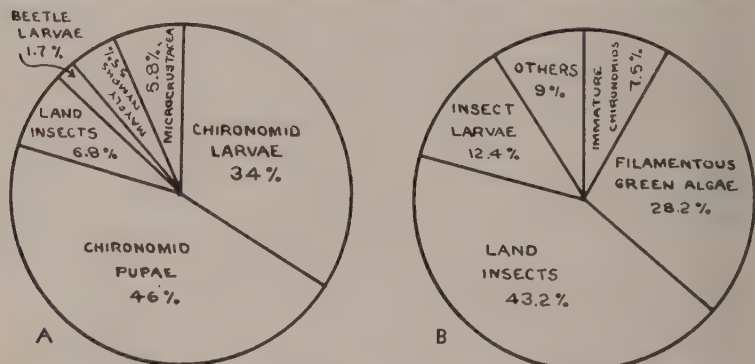


FIG. 37. A: Stomach contents of 18 Blue Lake trout fingerlings (3 to 5 cm.) taken September, 1940. B: Stomach contents of 17 Blue Lake minnows, *Rhinichthys oscula*, taken July, 1941.

young trout for food. In this connection, a considerable overlap was found to occur between the food of minnows and of trout fingerlings in Blue Lake. A series of young trout, 3 to 5 cm. long, was seined from around the shore of the lake in September of 1940, shortly after they had been introduced from the hatchery. The results of the analysis of the food in their stomachs is given in Figure 37-A. The series of minnows which was taken at the same time for comparison of feeding habits was not well enough preserved for study, but another series, taken in mid-summer of 1941, was studied, and the results will be found in Figure 37-B. While neither the young trout nor the minnows provide sufficiently extensive series for a reliable index of their foods during the summer,

they nevertheless do show, without question, that the minnows eat the sort of thing upon which the small trout were feeding, and probably compete severely with them. The paucity of organisms in the littoral zone of Blue Lake has been pointed out.

Stomachs from 61 trout, 30 to 50 cm. long, were collected at Heenan Lake in 1941, between mid-June and mid-September. They were consistently alike over that period, and have all been lumped together into a single series. The results from their analysis is given in Figure 38.

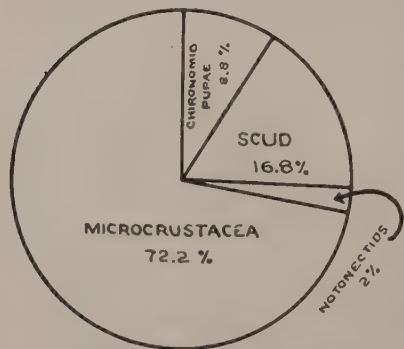


FIG. 38. Stomach contents of 61 Heenan Lake trout (30 to 50 cm. long) June 15 to September 17, 1941.

Plankton crustacea (daphnia and copepods) were the major constituent of the diet of these fish, in marked contrast to the situation found at Blue Lake, where the bottom fauna was the primary food source, with immature chironomids the major food. This is particularly interesting in the light of the limnological differences between the two lakes which have been pointed out. The complete absence of terrestrial insects from the Heenan Lake stomachs is surprising, particularly inasmuch as trout were seen to feed on the surface of the lake on several occasions, and at times they could be taken on flies, so that such forms must be of some minor importance in the diet of the fish. It was not unusual to find individual stomachs from Heenan Lake trout containing large numbers of scud. Such stomachs were almost never encountered at Blue Lake. Chironomid larvae and pupae were of minor importance during the summer, but may have been of more significance earlier in 1941, before sampling began. They were plentiful in bottom samples from Heenan Lake taken in mid-June.

Summary

The black-spotted trout in Upper Blue Lake, a deep granite basin at 8,130 feet elevation, subsisted largely on chironomid larvae and pupae. They failed to utilize the rather abundant population of the minnow, *Rhinichthys oscula*, which competes with young trout for food.

The trout of Heenan Lake, a former grazing meadow at 7,100 feet transformed by a dam into a 25-foot deep reservoir, subsisted largely on plankton crustacea (daphnia and copepods). The extremely abundant bottom fauna of the littoral zone provided only 17 per cent of their food (scuds of the *Gammarus* type); immature chironomids, plentiful in bottom samples, less than nine per cent.

Heenan Lake trout were in much better condition than those of Blue Lake, reflecting the relative richness of the two lakes.

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THE BOTTOM FAUNA OF BLUE LAKE, CALIFORNIA

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Upper Blue Lake is in Alpine County, California, at an elevation of 8,130 feet in the Sierra Nevada. It is a natural granite basin across the outlet of which a 28-foot dam was built in 1881. In Figure 39 the original shore-line is represented approximately by the 8.4 meter contour. It has a surface area of 344 acres, and a maximum depth of 54 meters (177 feet). It is a typical oligotrophic lake (cf. Welch 1935, p. 310): deep, clear, rich in dissolved oxygen, poor in dissolved nutrient materials. Limnological observations during two summers have been summarized in a previous paper (Calhoun, 1944.1).

A quantitative evaluation was made in 1940 of the standing crop of bottom fauna of Blue Lake—as Upper Blue Lake will hereafter be called in this paper for convenience—in connection with a study of its black-spotted trout (*Salmo clarkii henshawi*). The bottom organisms were found to constitute the trout's primary source of food (Calhoun, 1944.2). Bottom samples were collected with a standard 6-inch Ekman dredge. A series of 24 bottom samples was taken between July 13 (five weeks after the ice went out) and August 8, and a series of 21 samples during the second week of September. Dredging was done for the most part along the traverse line A-B (Fig. 39). A few samples in each series were collected in other parts of the lake, designated by appropriate letters in Figures 39, 40 and 41.

During the bottom sampling the water surface was approximately at the 4-meter contour (Fig. 39), which constitutes the "zero" reference point for all depths mentioned hereafter. From this shoreline to a depth of about 4 meters, in other words down to the original shoreline prior to construction of the dam, the bottom was a gravelly sand too highly consolidated to permit sampling with an Ekman dredge. For that reason this zone was excluded from the quantitative study. Frequent observations indicated that few organisms were present around the shore except at the creek mouths. At depths between 4 meters and 8 meters (13.1 feet and 26.2 feet), there was a transition from gravel to silt. Beyond 8 meters the bottom was a fine silt, with varying amounts of wood particles, except along the precipitous northeastern shore of the lake, where a lava talus slope extended down to a depth of 20 meters (65.6 feet) in some places.

A bed of *Nitella* or some closely related alga extended the length of the southwestern shore. It was sharply confined to a narrow zone between depths of 6 and 9 meters (19.7 and 29.5 feet).

Dredge samples were screened through a 30 mesh copper screen. The portion of the sample retained by this screen was transferred to a white-enamel pan, from which the organisms were picked out, sorted,

¹ Submitted for publication, December 1943. The work on which this paper is based was done under the auspices of the California State Division of Fish and Game, in partial fulfillment of the requirements for the degree of Doctor of Philosophy at Stanford University.

counted, and preserved in 70 per cent alcohol. Later, the volumes of the various components of each sample were determined by the displacement of water in a burette, after excess alcohol had been removed by placing the organisms momentarily upon a blotter. In transposing to units of weight, it was assumed that the specific gravity was one. This has been found to be approximately correct for organisms of the kinds involved (Davis, 1938, p. 12; Cooper, 1940, p. 65). Tables 1 and 2 contain the results of the analyses of the two series of bottom samples. The forms have been separated into four arbitrary categories, and for each sample the number and volume of each category has been given, as well as the total volume and number for the sample.

There were few kinds of organisms present on the lake bottom, particularly in deep water. At depths greater than 15 meters (49.2 feet), the only forms found were immature chironomids (*Chironomus* sp. near *cristatus* and *Procladius* sp.),² and tubifex worms. At depths of

² Identified by O. A. Johannsen, Cornell University. Chironomids are small two-winged flies which deposit their eggs in water, where the whole larval life is passed. The larvae are sometimes called "blood-worms."

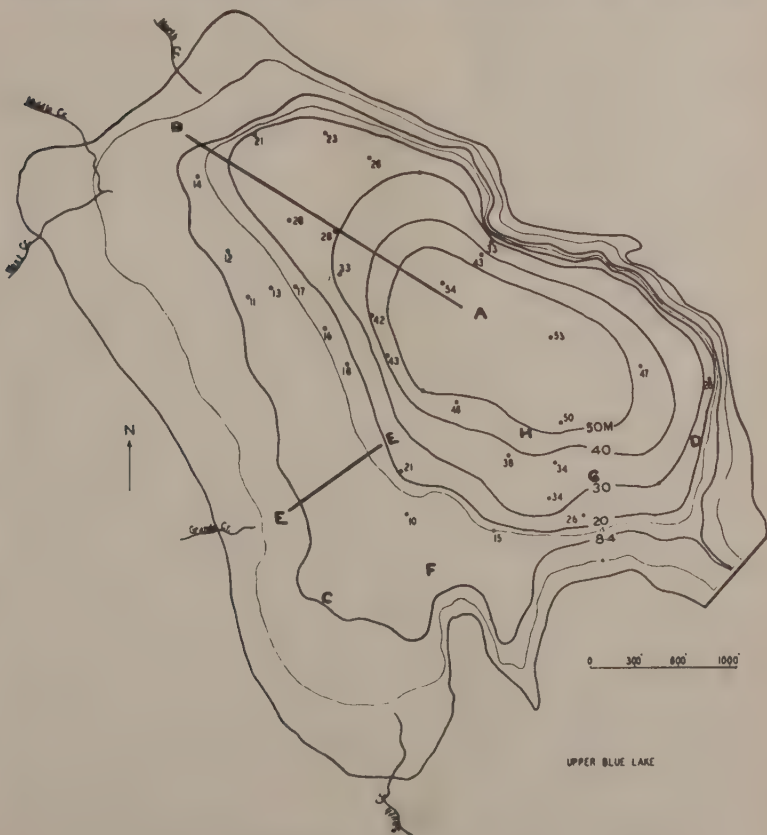


FIG. 39. Map of Upper Blue Lake. Depths are shown in meters (1 meter = 3.28 feet).

TABLE 1

Bottom Samples, Blue Lake, July 13 to August 8, 1940

Volumes (in cc.) and numbers of organisms per 1/4 square-foot dredge

Location*	Depth	Chironomus sp. near cristatus		Other chironomids		Tubifex worms		Other forms**		Total	
		Vol.	Number	Vol.	Number	Vol.	Number	Vol.	Number	Vol.	Number
A-B	42 m.	.07	7	.03	4	.18	25			.28	36
A-B	7	.12	12	.04	17	.01	47			.17	76
A-B	6.5	.02	4	.03	15	.03	18	.01	3	.09	40
A-B	0.25			.03	38					.03	38
A-B	16	.30	26	.11	45	.01	29			.42	100
A-B	11	.45	48	.04	16	.10	17			.59	81
A-B	13	.18	17	.02	15	.10	26			.30	58
A-B	20	.18	19	.01	4	.07	21			.26	44
A-B	27	.08	5	.005	2	.10	9			.19	16
A-B	39	.08	7			.15	31			.23	38
A-B	50					.005	1			.005	1
A-B	9.5	.51	54	.04	22	.04	9	.01	1	.60	86
A-B	13	.39	34	.01	4	.07	9			.47	47
A-B	6			.06	61	.07	11	.09	9	.22	81
A-B	10	.52	46	.07	19	.10	11			.69	76
A-B	8.5	.20	23	Not det	ermined	Not det	ermined	Not det	ermined	Not det	ermined
A-B	27	.42	35	.01	3	.05	8			.48	46
E-E	7	.21	19	.03	39	.05	28	.02	5	.31	91
E-E	6	.10	14	.11	101	.02	15	.06	5	.29	135
E-E	13	.23	18	.11	80	.01	3			.35	101
E-E	14	.16	33	.01	4	.02	14	.01	4	.20	55
F	14.5	.13	23	.13	93	.01	10			.27	126
G	32	.10	6	.01	3	.02	13	.01	1	.14	23
H	48			.02	5	.19	33			.21	39

* For locations see map in Figure 39, on which corresponding letters mark locations of stations. Where two letters are given, the sample will have been taken along the line connecting them, at the indicated depth.

** Gammarus, turbellarians and hydrachnids.

TABLE 2

Bottom Samples, Blue Lake, September 8 to 16, 1940

Volumes (in cc.) and numbers of organisms per 1/4 square-foot dredge

Location	Depth	Chironomus sp. near cristatus		Other chironomids		Tubifex worms		Other forms		Total	
		Vol.	Number	Vol.	Number	Vol.	Number	Vol.	Number	Vol.	Number
A-B	8.5 m.	.52	60	.06	27	.05	10	.02	4	.65	101
A-B	5.5	.14	58	.07	18	.02	22	.11	11	.34	109
A-B	12.5	.22	34	.04	21	.03	9			.29	64
A-B	16	.35	34	.04	17	.03	13			.42	64
A-B	26	.20	15		1	.08	12			.28	28
A-B	28	.17	19	.01	1	.09	24			.27	44
A-B	9.5	.59	54	.07	55	.07	13	.01	9	.74	131
A-B	14	.32	34	.04	19	.10	36		1	.46	90
A-B	20	.32	25	.01	4	.10	23			.43	52
A-B	34	.02	3			.07	6			.09	9
A-B	39	.08	10	.01	2	.25	41			.34	53
A-B	44		1	.02	4	.23	34			.25	39
A-B	49					.18	22			.18	22
A-B	51					.05	6			.05	6
A-B	7	.34	34	.10	32	.02	16			.46	82
A-B	10.5	.49	41	.09	39	.13	18			.71	98
A-B	32	.05	7	.02	3	.13	24			.20	34
E-E	12	.36	24	.10	69	.03	12	.05	22	.54	127
E-E	6	.11	28	.07	16	.01	6	.08	4	.27	54
C	7		1	.03	15	.02	16	.80	*45	.85	77
D	17	.39	31	.04	19			.02	9	.45	59

* Gammarus.

less than 15 meters, there were these as well as other chironomids (*Tanytarsus* sp., *Chironomus* spp. and *Psectrocladius* sp.)² and also a few *Gammarus*, hydrachnids and turbellarians. The predominant organism in the lake was the large red larva of *Chironomus* sp. near *cristatus*. A sharply developed zone of concentration of organisms between 7 meters (23 feet) and 15 meters (49.2 feet) resulted largely from an abundance of this form, particularly in terms of volume. The other, smaller chironomids were almost equally important from the standpoint of numbers present in this region. These relationships are shown in Figures 40 and 41, in which numbers and volumes of organisms, respectively, are plotted against depths of samples. This has been done in each figure for the different categories of organisms individually as well as for all forms collectively. The trends shown were drawn in "by eye," and are, of course, only approximate. These two sets of graphs are based on the data in Table 2, for the second series of samples. When the values for the earlier series in Table 1 are graphed in the same way, the results are almost identical, and they are not included for that reason. The great similarity between the two series is interpreted to indicate both a high degree of stability of the bottom fauna during summer and early autumn and a satisfactory degree of accuracy of the method used.

The situation shown in these two sets of graphs resembles closely the one found by Eggleton (1931) in Douglas Lake and Third Sister Lake in Michigan. He found a similar zone of concentration, and showed that the reduction in the amounts of organisms with increase in depth beyond this zone was a result of unfavorable conditions in the deeper hypolimnion during the period of summer stagnation. This is probably equally true for Blue Lake. The marked decrease in numbers and volumes of organisms on the shallow side of the zone of concentration in Blue Lake appears to be correlated with the change in the nature of the bottom, which has been discussed. Depth alone can not be the important factor, because the organism largely responsible for the zone of concentration, *Chironomus* sp. near *cristatus*, occurred abundantly on the muddy bottom of nearby Heenan Lake at depths between 2 and 4 meters (6.6 and 13.1 feet).

The considerable differences in the amounts of organisms present in different depth-zones in the lake made it impossible to arrive at any reasonable estimate of the amount of bottom fauna in the lake as a whole from any simple numerical average of all samples. The following procedure was carried out in order to obtain the estimates in Table 3. The lake was divided into four depth-zones, as shown in the first column of this table. The areas of these zones were determined on the basis of the depth contours in Figure 39. The average number of organisms in a given zone was derived from the bottom curve in Figure 40, as follows. The curve was transposed to a sheet of graph paper on which one unit was equal to one meter on the abscissa and five organisms on the ordinate. The mean ordinates under the four segments of the curve corresponding to the four depth-zones were estimated by counting the number of entire squares falling between a given segment and the abscissa, adding to this an estimate of the number of entire squares equivalent to the area represented by incomplete squares along the curve, and dividing the sum (the area under the curve) by the number of vertical columns of squares (the number of meters in the zone).

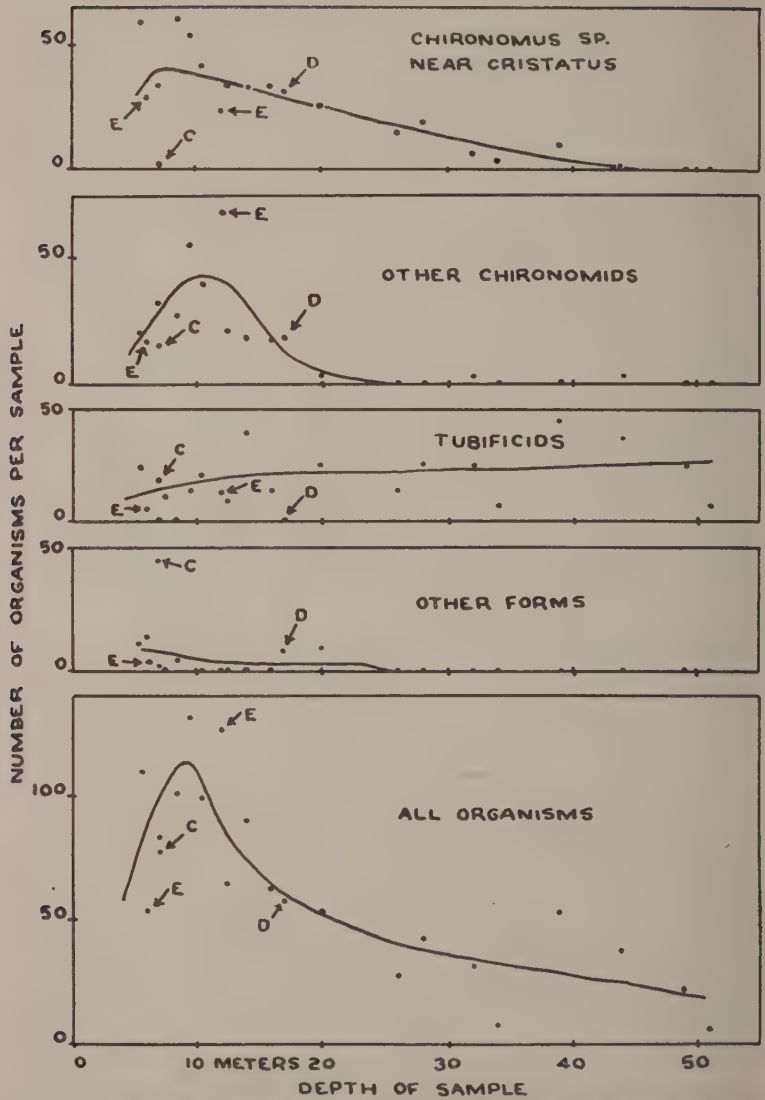


FIG. 40. Relationships between numbers of organism and depth of sample for the 21 samples in Table 2.

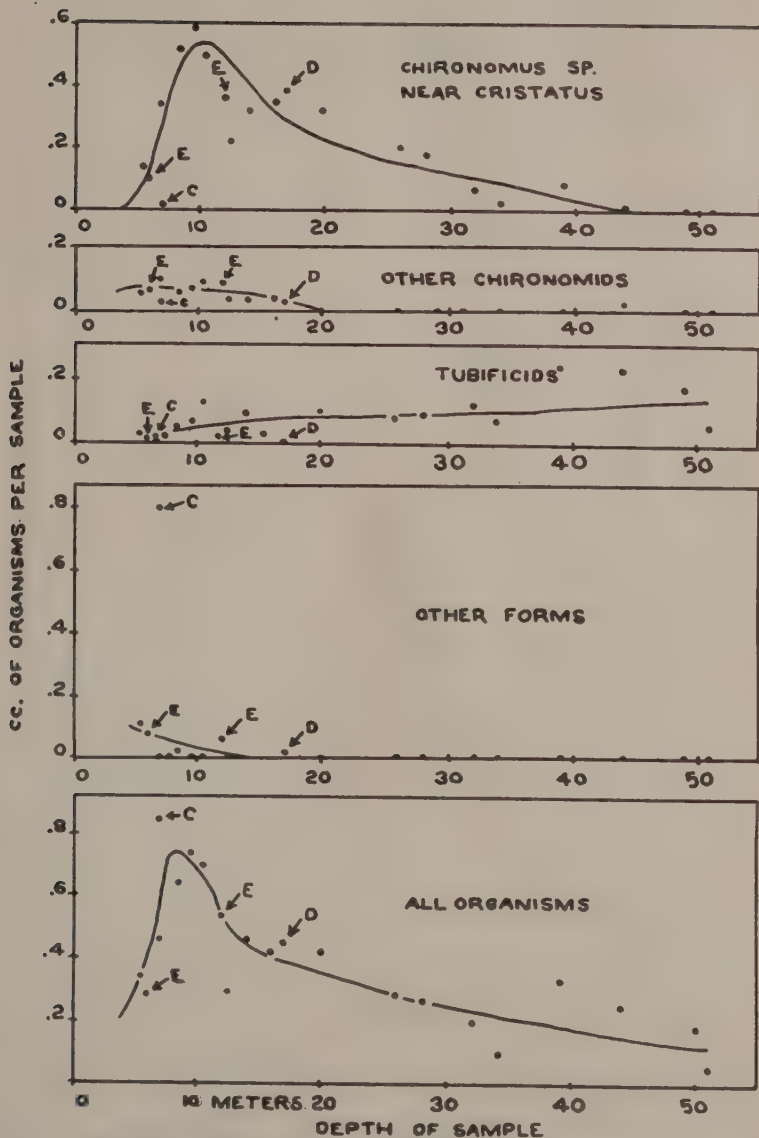


FIG. 41. Relationships between volumes of organism and depth of sample for the 21 samples in Table 2.

These mean ordinates are the values which have been used for the mean numbers of organisms in the four zones in Table 3.

TABLE 3
Standing Crop of Organisms in Blue Lake

Depth zone	Area of zone	Mean number organisms per sample	Number per square meter	Millions per acre	Millions in zone	Mean cc organisms per sample	Pound per acre wet weight	Pounds in zone
4-15 m.-----	128 A.	88	3,793	15.35	1,964	.481	224	28,672
15-30-----	52	49	2,112	8.54	444	.240	112	5,824
30-40-----	36	32	1,379	5.58	202	.048	22	792
40+-----	50	25	1,078	4.36	218	.020	9.3	465
4+-----	266	-----	*2,627	-----	2,828	-----	**134.4	35,763

* Summation of column 6 divided by combined area of all zones, in square meters.

** Summation of column 9 divided by combined area of all zones, in acres.

The same procedure was followed in arriving at the estimates of the volumes of organisms in Table 3. In this case the bottom curve in Figure 41 was used.

The estimates for the lake as a whole were derived by adding the totals for the four zones and dividing the sum by the total area of the four zones, in the appropriate units. The average wet weight of organisms for the lake as a whole, beyond a depth of 4 meters, was 134 pounds per acre. According to Rawson (1930), this is roughly equivalent to 27 pounds per acre dry weight. The estimated number of organisms per square meter of lake bottom was 2,627.

The number of western lakes for which quantitative estimates of the bottom fauna have been derived is limited. A comparison with such results as are available indicates that Blue Lake supports a good fauna per unit of area for a deep, oligotrophic lake of its size.

The bottom fauna of Paul Lake, British Columbia (Rawson, 1934) offers a fairly close parallel to that of Blue Lake. The figure of 32.5 pounds per acre dry weight as an overall estimate can not be considered to differ significantly from the corresponding figure of 27 pounds for Blue Lake. On the other hand, the estimate of 1,363 organisms per acre was only about half the figure for Blue Lake, which was 2,627. Moreover, the types of animals comprising the fauna in Paul Lake were somewhat different. *Hyallala*, *Gammarus* and various molluscs formed a significant element. In Blue Lake, *Gammarus* was of minor importance, and no *Hyallala* or molluscs were found. Two rare species of mollusc are reported to occur in Blue Lake,³ but I was unable to find them.

Lake Arrowhead, California (Needham, 1937) offers an interesting comparison with Blue Lake. It has essentially the same limited sort of fauna, with chironomids predominating. The area of the lake is 750 acres, the elevation is 5,102 feet, and the maximum depth is 150 feet. Needham's samples indicate the low figure of 9.1 pounds of organisms per acre, wet weight, which is only about $\frac{1}{15}$ the amount found in Blue Lake. Needham does not include tubifex worms in his figures, but that could account for only a very small portion of such a difference. As he

³ Personal communication from G. D. Hanna, California Academy of Sciences.

points out, the fact that the samples were taken in late November, when a bottom fauna of this sort would be at a minimum as a result of the emergence of the chironomids, might be at least partially responsible for the small numbers of bottom organisms found.

The only lake at all near Blue Lake for which an estimate of the bottom fauna is available is Angora Lake, north about 25 miles, at an elevation of 7,800 feet. Needham and Sumner (1942) estimated that it averaged only 49 pounds per acre, wet weight, and 1,667 individuals per square meter. The lake has an area of about 5 acres, and a maximum depth of 50 feet. The same types of organisms were present as at Blue Lake, except that *Hyallela* replaced *Gammarus*. Considering its small size and its shallowness, both factors which would be expected to increase the bottom fauna, Angora Lake appears to be considerably less productive than Blue Lake.

Curtis (1934) gives data for one of the Cottonwood Lakes (Lake 4), in California, at an elevation of 11,000 feet. The greatest depth of this lake is 43 feet, and its area is 33 acres. Curtis estimates an average of 155 pounds per acre, wet weight, of the *Chironomus tentans* type of larva alone. When allowance is made for the smaller size of this lake, and the shallowness of its basin, compared to Blue Lake, the two appear to be on about the same level of bottom fauna production.

Summary

The bottom fauna of Blue Lake at depths greater than 4 meters was limited to chironomid larvae and pupae, *Gammarus*, hydrachnids, turbellarians, and tubifex worms. Over 50 per cent by volume consisted of immature *Chironomus* sp. near *cristatus*. The greatest concentration of organisms centered at a depth of about 10 meters. There was a sharp decline in amount above 8 meters and below 12 meters. The average wet weight of organisms for the lake as a whole, beyond a depth of 4 meters, was 134 pounds per acre. There were an estimated 2,627 organisms per square meter of lake bottom. Blue Lake supports a good bottom fauna for a lake of its size, type and location.

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SELECTIVE BREEDING OF RAINBOW TROUT AT HOT CREEK HATCHERY ¹

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California Division of Fish and Game*

As is well known, Rainbow trout in California ordinarily spawn during the spring of the year. Sometimes at high elevations spawning may occur as late as June or early July. Undoubtedly the spring spawning habit of the Rainbow in California is that best adapted to natural conditions. However, artificial propagation in hatcheries and rearing ponds is difficult where eggs are obtained during the late spring months. Where cold hatchery waters are used the resulting fish may be only one and one-half or two inches in length by early August and fish of catchable size can only be produced by holding the fish in ponds through the following winter.



FIG. 42. Hot Creek Hatchery in winter.

At Hot Creek in Mono County four springs provide water ranging from 55° to 63° F., each spring being constant in temperature throughout the year. With the development of our trout hatchery there, it became apparent that great advantage could be obtained if eggs from fall spawning Rainbow were available. Fish hatched in the fall would, in waters of these temperatures, continue rapid growth throughout the winter, and be four to six inches long by the middle of the following summer when planting could be done most advantageously.

It was known that such fall-spawning Rainbow strains had been developed at Springville, Utah, by the U. S. Bureau of Fisheries, now the Fish and Wildlife Service, and through their assistance eggs from this stock were obtained for the Hot Creek Hatchery. The resulting fish

¹ Submitted for publication, January, 1944.

were two years old in the fall of 1935. At that time about 20 per cent of the prospective brood stock females had eggs, but the eggs could not be successfully taken from the fish because they were slow in coming free in the ovaries. These brood fish were being held in a pond of 60° water. Wild trout in the springs were tested and it was found that good eggs could be taken in the springs of lower temperatures. Accordingly, the brood fish were moved into a pond of 56° water in January, 1936, and in the autumn, at the age of three years, were spawned successfully. No selective work was done in connection with spawning at this time. The fingerlings were raised in ponds on natural foods throughout the ensuing winter. In the spring of 1937 they were graded and the best of them held for future brood stock selection.

Definite plans were made for selective breeding in 1938. It was resolved to select rapidly growing fish which produced a large number of eggs at two years of age, with these ideas in mind: to obtain a high percentage of females spawning at two years; to increase the egg production per female; and, by selecting the largest two year olds, to develop a strain that would make rapid growth. The shape, size and color of the select fish was also taken into consideration.

This work was carried on by breeding two year old selected fish every second year to develop brood stock for the next generation. To keep the spawning season within the same months each year, fish for the future stock were chosen from those spawning on or near October 25th.

In the fall of 1938 the first generation of Rainbow brood fish from eggs taken at Hot Creek Hatchery was two years old, and 53 per cent of the females spawned. On October 25, 1938, 48 of the best females were chosen and bred with males that had made the most rapid growth. The eggs were hatched as a lot and the fingerlings kept together until the spring of 1939 when 5,000 of them were graded from this group and put into the brood pond for future stock. In the fall of 1940, at the age of two years, 95 per cent of the resulting females spawned, and on October 25th the second selection was made. Twenty-five females were chosen for the same qualities as in 1938, and the same procedure was followed with eggs and fingerlings.

The resulting two year olds were ready for their first spawning in the fall of 1942. On October 23d, 60 females were picked for size and for number of eggs produced; but a new method was used in handling the eggs. It had become apparent that losses in the eyed eggs at Hot Creek were higher than normal, running from 15 to 35 per cent in the different lots and resulting in large part at least from poorly developed embryos. Various causes were suspected, including types of food given the parent fish, and long periods spent in warm water between spawnings. Experiments were run to check these sources of trouble and some corrections were found possible. Among other things it was discovered that a few fish produced eggs which were practically an entire loss; some, a normal loss; and some, nearly perfect eggs. It was concluded that the group handling of the selected eggs was a mistake and that better results could be obtained by segregating the eggs from each female.

Accordingly, the eggs from each fish in 1942 were counted and kept in separate compartments in egg trays in the hatchery. The losses of each lot were recorded until hatching time arrived. Just before the eggs hatched they were carefully picked to remove as many of the poorly

developed ones as possible. The eggs from four females were then selected, paying more attention to the quality than to the quantity. These eggs hatched 97.1 per cent. The egg losses from some of the rejected lots were as high as 80 and 90 per cent.

The results of the foregoing are set forth in condensed form in Table 1.

TABLE 1
Results of Selective Breeding of Two Year Old Fish

Year	Per cent of 2 year females spawned	Average number of eggs per female spawned in October	Number of females selected for brood stock development	Average number of eggs per selected female
1938 -----	53	723	48	958
1940 -----	95	1332	25	1782
1942 -----	98	1693	60	2106*

* Average production for four lots chosen for quality from the egg lots of the 60 selected females.

Table 1 sheds light on two of the objectives of the selective breeding plan. Fish spawning for the first time at two years of age have been increased from 53 per cent to 98 per cent in three generations. Egg production has been raised from 723 per two year old female to 1,693 per two year old female, in the ratio of 2.34 to 1. (Egg production of the selected females in the last column is less significant, since they are merely the heaviest producers of each year—except in 1942 when quality was considered more important than quantity, and when on the latter basis alone the figure would have been 2,637 per female.) This increase in egg production is evident also in the older fish. In 1941, 13 three year olds averaged 2,112 eggs per fish, and in 1943 nine three year olds averaged 3,072 eggs per fish. These counts were from females individually selected for eggs of good quality as well as quantity.

That selection of rapidly growing fish for brood stock has increased the growth rate is shown in Table 2.

TABLE 2
Average Weights of Selected Yearlings on October 1 *

Year	Average Weight of Fish
1939 -----	5 ounces
1941 -----	6 ounces
1943 -----	8 ounces

* Eggs taken in October of the preceding year.

The hatchery and rearing ponds were rebuilt in 1941. Before that date operations were carried on under very crowded conditions and the advantages given by the changes made in 1941 make it difficult to present comparative figures of growth from year to year, but the fish raised for planting show results similar to those given in the above chart.

It is possible that a few more generations of selective breeding of Rainbow brood fish will bring greater increases in the egg production and that through individual selection of the parent fish, the quality of the eggs can be greatly improved. There is little doubt that greater progress can be made to increase the growth rate of fingerlings through selective breeding of brood fish.

EDITORIALS AND NOTES

SKULL OF A CALIFORNIA GRIZZLY

A paper by Dr. E. Raymond Hall, "The Grizzly Bear of California," published in this magazine in July, 1939, calls attention to the great rarity in museum collections of specimens of this now extinct form and emphasizes the scientific importance of securing additional remains. Even such material as the Museum of Vertebrate Zoology possesses is largely of a fragmentary nature; Grinnell, Dixon and Linsdale (*Fur-Bearing Mammals of California*, Vol. 1, p. 68, Univ. Calif. Press, 1937) list only two complete skulls. For this reason, it seems worth while to add details of another complete skull (Fig. 43) at present in the collection of the Museum of Comparative Zoology at Harvard. The Peabody Museum at Salem, Mass., formerly owned this specimen, but disposed of it when it decided to limit its natural history exhibits.

Written on the skull in faded but still legible ink is the following: "Ursus horribilis Ord. Grizzly Bear. California pres. by W. O. Potter May 15, 1862." A tag with it indicates that it was one of the skulls studied by C. Hart Merriam in 1915 when working on the grizzly bears although it does not have his identification. Dr. Thomas Barbour of the Museum of Comparative Zoology states that Dr. E. S. Morse, formerly Director of the Peabody Museum, told him that tradition had it that the bear was killed in the hills not far from San Francisco. Unfortunately, the date on the skull appears to refer to the time when the skull was presented to the museum and not to when the animal was killed.

Measurements in millimeters are as follows: Total length, 410; basilar length, 345; palatilar length, 179.2; greatest length of nasals (not exact as the naso-frontal suture is ossified), 101; zygomatic width, 221; mastoid width, 172.5; width of braincase, 108; interorbital width, 79; width across postorbital processes, 129.8; length of upper cheek teeth (from anterior border of canine to posterior border of M^2), 144; width across upper cheek teeth, 91.4; crown length of M^1 and M^2 , 59.7; crown length of M^2 , 36.2; length of lower cheek teeth, 159.—*Barbara Lawrence, Museum of Comparative Zoology, Harvard College, Cambridge, Massachusetts, October, 1943.*

A "SPECIMEN" OF GRIZZLY BEAR FROM ALAMEDA COUNTY, CALIFORNIA

Specimens of grizzly bears from California are so few in museums that any are of interest even if incomplete. On July 10, 1943, I found a third right lower molar of a grizzly bear in Corral Hollow, one and one-half miles east of Tesla, Alameda County, California. The tooth was lying on the surface of the sand and gravel of the wash and probably had been carried from upstream by flood waters. Other fragments from the same individual are doubtless scattered along the watercourse but the chance of finding any of them seems small. A search in the



FIG. 43. Skull of California grizzly bear, M. C. Z. 41998. Photograph by Charles Darling.

vicinity for other parts was fruitless. The tooth is in excellent condition except for small surface cracks. It is therefore reasonable to suppose that the tooth had been buried until recently as teeth usually fall to pieces in a short time when exposed to sunlight and heat. The crown surface is almost unworn, indicating that it was from a young individual. The crown is 23 mm. long and 16 mm. wide. This indicates that the tooth came from one of the larger kinds of grizzlies and is support for the supposition that it came from one resident in the vicinity, since it is known that grizzlies in California were larger than those from most other areas. There is, however, much individual variation in the size and shape of the third lower molar in all kinds of grizzlies. The identification of the tooth as that of a grizzly is certain, but it is not possible at present to determine the specific or racial identity of the tooth. According to present knowledge of distribution, and the present nomenclature, and assuming that the specimen actually is from a bear which lived in the vicinity, the tooth represents a specimen of *Ursus californicus*, *Ursus colusus*, or *Ursus tularensis*.

This tooth is the only "specimen" known to me of a grizzly bear from Alameda County, but it does not furnish a new record of locality. Rather, it substantiates some published records that grizzlies were once present in Corral Hollow. In T. H. Hittell's "Adventures of John Capen Adams: Mountaineer and Grizzly Bear Hunter of California" (Charles Scribners Sons, 1926) there is an account (pp. 301-305) of the killing in 1855 of a female and two cubs in "Devil's Den," in which place in Corral Hollow was a bed of coal and a sulfur spring. This locality may be the present coal mine of Tesla, but I have not attempted to learn if there are other coal beds and sulphur springs in the vicinity. The tooth was found a mile and a half downstream from Tesla. It can hardly be assumed, of course, that it is from one of the bears killed by Grizzly Adams.

The last record for Corral Hollow is 1861. This is cited in Grinnell, Dixon, and Linsdale's "Fur-bearing Mammals of California" (University of California Press, 1937) on page 81, and refers to an old companion of Grizzly Adams who was "badly used by a bear last spring."

It is possible that some members of the families of pioneer settlers have knowledge of later occurrences of grizzlies in the vicinity and may even possess specimens. Dr. E. Raymond Hall, in an article concerning grizzly bears in California (California Fish and Game, vol. 25, 1939, pp. 237-244) has pointed out the scarcity of specimens of California grizzlies and the desirability of preserving any existing specimens in a safe place and making them available for study. It is also desirable that any definite and trustworthy information concerning grizzlies and their habits be placed on record.—Seth B. Benson, *Museum of Vertebrate Zoology, University of California, October, 1943.*

DIAMOND-BACK TERRAPIN INTRODUCED INTO CALIFORNIA

Diamond-back terrapin, highly rated as a table delicacy in the eastern United States, were planted in California on May 13, and May 30, 1943. The first lot consisted of 485 yearlings and the second of 77 adults, of which 52 were females and 25 males. Both lots were obtained through the cooperation of the U. S. Fish and Wildlife Service, the



FIG. 44. Diamond-back terrapins. Male above, female below.

yearlings having been raised at their station at Beaufort, North Carolina and the adults purchased from commercial dealers in the same area. The introduction of terrapin was initially suggested by the Consolidated Sportsmens Clubs of the Peninsula through their secretary, Mr. G. W. Philpott of San Mateo, and the club by supplying funds facilitated purchase of the adults.

The locality chosen for the planting was an unnamed island lying just off shore from Radio Station KPO in the southern part of San Francisco Bay between the mouths of Belmont and Steinbergen Sloughs. The island is about 1700 yards long and 350 yards wide. At high tide all but

the westernmost portion is submerged. Lowlying marsh lands of this type are the habitat of the animals on the Atlantic coast and similar types of food such as mussels and small crabs are abundant. The island is thickly covered with marsh vegetation, so much in fact, that the animals have a great abundance of cover and will be extremely difficult to find.

On October 9, 1943, a trip was made to the island by two observers. Careful search was made over the west end of the island and along the offshore side but no signs of terrapin could be found. A previous introduction of terrapin was attempted in 1896, when 129 of the animals were brought to California and planted in an unrecorded locality on San Francisco Bay. The present planting will be more carefully followed to determine the success of the introduction.—*A. C. Taft, Chief, Bureau of Fish Conservation, California Division of Fish and Game, January, 1944.*

IN MEMORIAM

RICHARD DE LARGE

The career of Richard DeLarge, Lieutenant, United States Army Air Force, came to a tragic end on February 24, 1944, at Douglas Air Base, Arizona, when the plane in which he was instructing an aviation cadet in night flying crashed because of motor failure coming into a landing.

Born in Omaha, Nebraska, on May 14, 1918, DeLarge grew up in Los Angeles, where he attended the John Marshall High School and the Glendale Junior College. After working for the Citizens National Bank of Los Angeles and the Southern California Gas Company, he joined the staff of the California State Division of Fish and Game in 1940 and was stationed at Mt. Whitney Fish Hatchery with the rank of Assistant Warden. He enlisted in the Army Air Corps in May of 1942, but was not called to duty until January of 1943. He received his training in California and at Douglas, Arizona, where he was commissioned November 3, 1943. He immediately became an instructor at that field, and up to the time of the fatal accident had made full-fledged pilots out of 41 flying cadets.

He is mourned by his parents, Lula and Jules DeLarge, and by his many friends in the Division.—*A. C. Taft, Chief, Bureau of Fish Conservation, California Division of Fish and Game.*

REPORTS

FISH CASES

October, November, December, 1943

Offense	Number arrests	Fines imposed	Jail sentences (days)
Abalones: Undersize, no license, overlimit	6	\$145 00	
Angling: No license, closed stream, at weir, spear in closed area, use gaff and snag hooks, night fishing, illegally taken fish, possession of spear within 300 ft. of stream, at dam, failure to show fish on demand	52	985 00	140
Bass, black: No license, undersize	2	35 00	
Bass, striped: At night, undersize, two rods, no license, overlimit, before sunrise, in salmon net	17	310 00	
Clams: Undersize, in refuge	19	460 00	15
Commercial: Fail to pack minimum cases to the ton, no license	2	110 00	
Lobsters: Undersize, in traps	2	125 00	
Salmon: Overlimit, at night, illegally taken, at fish screen, no license, spearing, closed area, closed stream, other than angling	42	1,350 00	30
Pollution	1	300 00	
Totals	143	\$3,820 00	185

GAME CASES

October, November, December, 1943

Offense	Number arrests	Fines imposed	Jail sentences (days)
Bear: Closed season	1	\$25 00	
Deer: Closed season, doe, failure to complete deer tags, no deer tags, use tags of another, kill deer no permit, forked horn deer in District 1 $\frac{1}{2}$, refuge, no license, spike buck, spotlighting, fawn	99	6,770 00	20
Deer meat: Closed season, illegal, fail to have stamped	15	1,355 00	
Doves: Overlimit, closed season	4	60 00	30
Ducks: Closed season, failure to show game on demand, no license, early and late shooting, shooting from power boat, unplugged gun	114	4,762 50	55
Geese: Overlimit, unplugged gun	16	375 00	
Hunting: No license, false statement to secure license, transfer license, firearms on refuge, at night, unplugged gun, closed area	97	2,895 00	
Nongame birds	4	100 00	
Pheasants: Closed season, shooting from vehicle, no tags, use tags of another, no license, unplugged gun, use license of another	193	6,600 00	
Quail: Closed season, trapping	10	260 00	
Rabbit, Cottontail: closed season	1	25 00	
Sage hens	3	125 00	
Swans	2	50 00	
Trespassing	1	10 00	
Tree squirrel	1	100 00	
Shooting from public road and car	11	175 00	
Disturbing and removing traps of licensed trapper	1	50 00	
Trapping for profit, no license	3	30 00	
Totals	576	\$23,857 50	105

SEIZURES OF FISH AND GAME

October, November, December, 1943

Fish:	
Bass, black.....	2
Bass, striped, pounds.....	1,500
Clams.....	392
Clams, Pismo.....	66
Lobsters.....	7
Lobster traps.....	45
Salmon.....	6
Salmon, pounds.....	520
Salmon, king.....	25
Salmon, silver, pounds.....	45
Trout, rainbow.....	3
Trout, steelhead, pounds.....	13½
Game:	
Deer.....	36
Deer meat, pounds.....	433
Doves.....	162
Ducks.....	540
Ducks, mallard.....	3
Ducks, pintail.....	92
Ducks, sprig.....	16
Geese.....	51
Pheasants.....	10
Pheasants, hen.....	48
Pheasants, male.....	199
Quail.....	7
Rabbits, cottontail.....	1
Sage hens.....	2
Squirrel.....	1
Swan.....	1
Wood duck.....	2

(Continued from inside front cover)

BUREAU OF ENGINEERING

JOHN SPENCER, Chief	San Francisco
Clarence Elliger, Assistant Hydraulic Engineer	San Francisco
Samuel Kabakov, Junior Civil Engineer	San Francisco

BUREAU OF LICENSES

H. R. DUNBAR, Chief	Sacramento
L. O'Leary, Supervising License Agent	Sacramento
R. Nickerson, Supervising License Agent	Los Angeles
Lorraine Atwood, License Agent	San Francisco

ACCOUNTS AND DISBURSEMENTS

D. H. BLOOD, Departmental Accounting Officer	Sacramento
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BUREAU OF PATROL

E. L. MACAULAY, Chief of Patrol (absent on military leave)	San Francisco
L. F. CHAPPELL, Chief of Patrol	San Francisco

CENTRAL DISTRICT (Headquarters, Sacramento)

C. S. Bauder, Inspector in Charge	Sacramento
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Northern Division

A. A. Jordan, Captain	Redding
Jos. H. Sanders, Captain	Sacramento
A. H. Willard, Captain	Rocklin
E. O. Wraith, Captain	Chico
L. E. Mercer, Warden, Butte County	Chico
Taylor London, Warden, Colusa County	Colusa
Albert Sears, Warden, El Dorado County	Placerville
E. C. Vail, Warden, Glenn County	Willows
Don Davison, Warden, Modoc County	Alturas
Earl Hiscox, Warden, Nevada County	Nevada City
Nelson Poole, Warden, Placer County	Auburn
E. J. Johnson, Warden, Plumas County	Quincy
Charles Sibeck, Warden, Sacramento County	Sacramento
Earl Caldwell, Warden, Shasta County	Burney
Don Chipman, Warden, Siskiyou County	Dunsmuir
Brice Hammack, Warden, Siskiyou County	Yreka
Louis Olive, Warden, Lassen County	Susanville
Fred R. Starr, Warden, Siskiyou County	Dorris
R. E. Tutt, Warden, Sierra County	Downieville
R. W. Anderson, Warden, Tehama County	Red Bluff
C. L. Gourley, Warden, Trinity County	Weaverville
C. O. Fisher, Warden, Yolo County	Woodland
R. A. Tinnin, Warden, Yuba County	Marysville
Wm. LaMarr, Warden, Placer County	Tahoe City
Rudolph Gerhardt, Warden, Butte County	Gridley
K. Langford, Warden, Sutter County	Meridian
Walter Krukow, Assistant Warden, Shasta County	Redding

Southern Division

S. R. Gilloon, Captain	Fresno
John O'Connell, Captain	Stockton
R. J. Little, Warden, Amador County	Pine Grove
L. R. Garrett, Warden, Calaveras County	Murphys
F. A. Bullard, Warden, Fresno County	Reedley
Paul Kehrer, Warden, Fresno County	Fresno
Lester Arnold, Warden, Kern County	Bakersfield
C. L. Brown, Warden	Fresno
Ray Ellis, Warden, Kings County	Hanford
H. E. Black, Warden, Madera County	Madera
Gilbert T. Davis, Warden, Mariposa County	Mariposa
Hilton Bergstrom, Warden, Merced County	Los Banos
Wm. Hoppe, Warden, San Joaquin County	Lodi
Geo. Magladry, Warden, Stanislaus County	Modesto
W. I. Long, Warden, Tulare County	Visalia
Roswell Welch, Warden, Tulare County	Porterville
F. F. Johnston, Warden, Tuolumne County	Sonora
Donald Hall, Warden, Kern County	Kernville